1. IC4.1 Part1: ENSO

Instructor Notes: Welcome to the first Lesson in Instructional Component 4, Climatology, in Advanced Warning Operations Course – Winter Weather Track. This first lesson will provide you an overview of the physical mechanisms responsible for slowly evolving large-scale winter events, and show you where to look to find the current climate system conditions and see predictions of the coming winter season. Specifically, In this first "sub-lesson, 1.1" we will look at El Niño, La Niña, and the Southern Oscillation, and see what effects these conditions have on US winter weather. In sub-lesson 1.2, we will discuss another, less well-known phenomenon known as the Madden-Julian Oscillation, and see it's effects on winter weather in the US. In sub-lesson 1.3, we will find out what "Teleconnections" are and why they are important in discerning expected winter weather, and finally, in sub-lesson 1.4, we'll take a look at products available from the Climate Prediction Center and the Climate Diagnostics Center that will help you in monitoring the current and expected state of the climate system which in turn will help you in the forecast process (or funnel) during the winter. Now let's start with ENSO.

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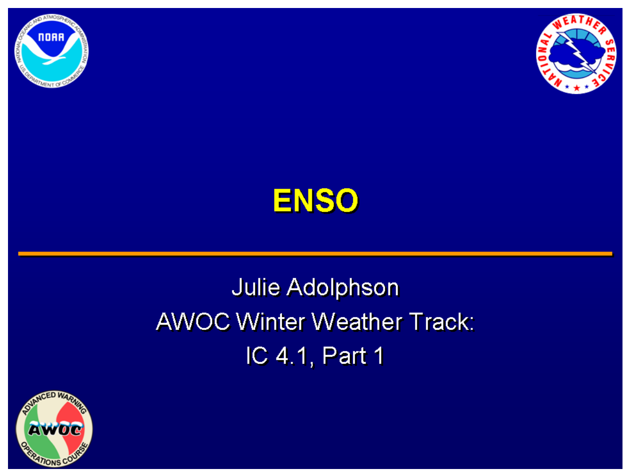

2. Purpose of Lesson 1.1

Instructor Notes: In this lesson we will discuss large temporal and spatial scale phenomena such as El Niño and La Niña, and how they influence US winter weather. We will also see their bearing on the evolution of winter time synoptic scale systems. I should mention right up front that the correlation between ENSO and expected winter time conditions is highest during moderate or strong episodes of ENSO.

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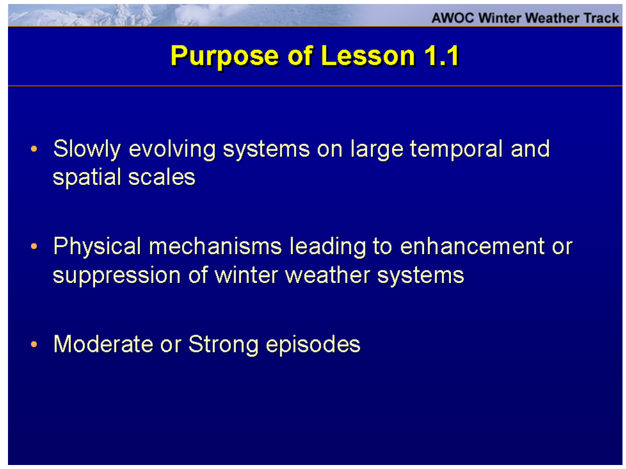

3. Lesson 1.1 Outline

Instructor Notes: We'll start with some definitions, see just where we find evidence of these phenomena, see what happens during warm and cold episodes, and then the expected synoptic patterns which occur during ENSO.

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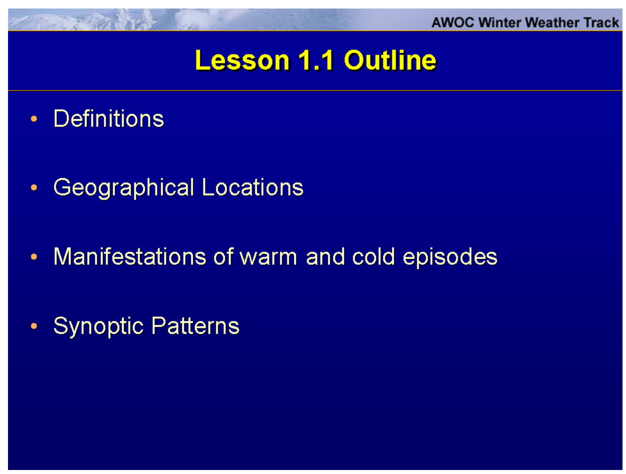

4. IC 4 Lesson 1.1 Learning Objectives

Instructor Notes: We will focus on helping you look at the "big picture" in space and time to help you assess the potential for upcoming winter storms in your area of responsibility. We'll see how these "slowly evolving" systems initiate and how they influence weather in the US. We'll also see how these phenomena are monitored, and in later sections we'll take a look at resources you can use to assess the state of the climate system and what the latest predictions are for the medium and longer ranges.

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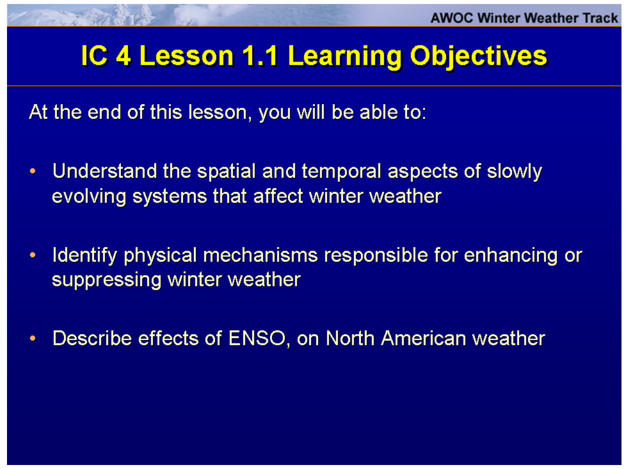

5. Performance Objectives

Instructor Notes: After this lesson you should be able to investigate the current state of the atmosphere in large temporal and spatial scales and correlate them to the potential (or lack thereof) of increased/decreased winter storms and the relationship between the "mode" of the climate system and what to expect for the season in terms of temperature and precipitation anomalies (or lack thereof). You will understand the mechanisms that contribute to an increased/decreased probability of winter time storms in your area. Finally, you will be able to distinguish between different types of teleconnections and understand what significance they have in the winter for the US.

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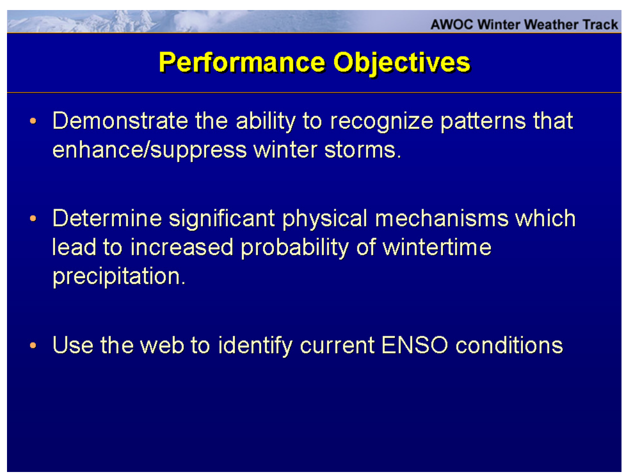

6. ENSO

Instructor Notes: This phenomenon was first noticed by coastal residents of Peru, which is the location of one of the world's most productive fisheries. Typically, in the first months of each year, a warm southward current modified the normally cool waters. But every few years, this warming started early (in December), was far stronger, and lasted much longer. Torrential rains fell on typically arid land. The productive fisheries failed.

This is El Niño, "the Christ child," so named because of its frequent late December appearance. Originally thought to affect only the narrow strip of water off Peru, it is now recognized as a large scale oceanic warming that affects most of the tropical Pacific. (Note: This image is from http://www.nhc.noaa.gov/aboutsst.shtml)

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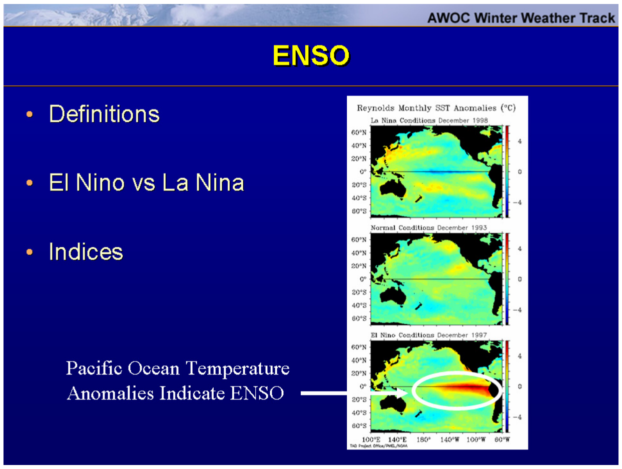

7. Recognizing/Measuring El Niño/La Niña

Instructor Notes: El Niño episodes (left hand column) reflect periods of exceptionally warm sea surface temperatures across the eastern tropical Pacific. La Niña episodes (right hand column) represent periods of below-average sea-surface temperatures across the eastern tropical Pacific. These episodes typically last approximately 9-12 months. Sea-surface temperature (top) and departure (bottom) maps for December - February during strong El Niño and La Niña episodes are shown above.During a strong El Niño ocean temperatures can average 2 degrees C – 3.5 degrees C (4 degrees F - 6 degrees F) above normal between the date line and the west coast of South America (bottom left map). These areas of exceptionally warm waters coincide with the regions of above-average tropical rainfall. During La Niña temperatures average 1 degrees C - 3 degrees C (2 degrees F - 6 degrees F) below normal between the date line and the west coast of South America. This large region of below-average temperatures coincides with the area of well below-average tropical rainfall.For both El Niño and La Niña the tropical rainfall, wind, and air pressure patterns over the equatorial Pacific Ocean are most strongly linked to the underlying sea-surface temperatures, and vice versa, during December-April. During this period the El Niño and La Niña conditions are typically strongest, and have the strongest impacts on U.S. weather patterns. El Niño and La Niña episodes typically last approximately 9-12 months. They often begin to form during June-August, reach peak strength during December-April, and then decay during May-July of the next year. However, some prolonged episodes have lasted 2 years and even as long as 3-4 years. While their periodicity can be quite irregular, El Niño and La Niña occurs every 3-5 years on average. (Note: image from http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.shtml) This page only goes to products but not further.

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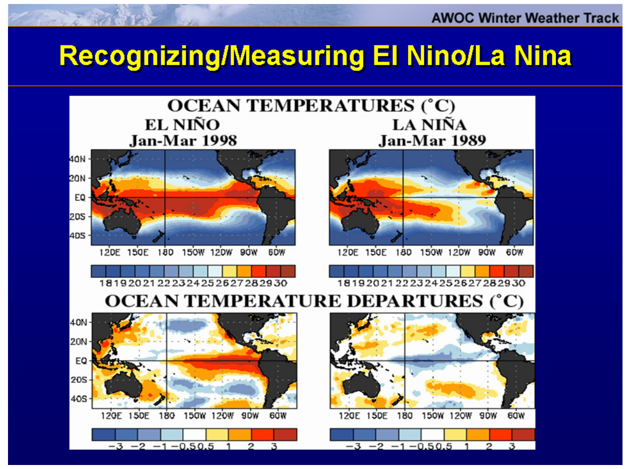

8. Identifying/Monitoring ENSO - Indices

Instructor Notes: One of the primary indicators of the oceanic state of ENSO is illustrated with Pacific SSTs. There are several Niño “regions” used to describe the state of the ocean. Niño 3.4 is the most often used index, stretching along the equator from 170 W to 120 W longitude, 5N to 5S latitude. Niño 3.4 captures the biggest changes in SSTs between ENSO events. (note: data shown from http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.shtml)

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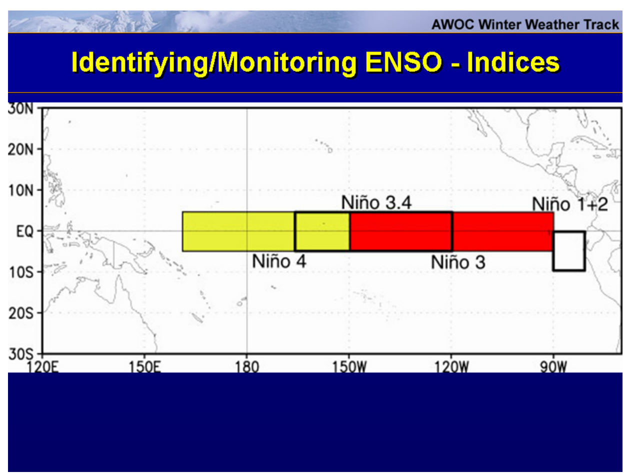

9. Tropical Atmosphere/Ocean Array

Instructor Notes: An inadequate understanding of the relevant physical processes and a lack of observational data covering vast areas of tropical oceans has hindered monitoring efforts in the past. Significant improvement of the observational data base was brought about by the Tropical Atmosphere/Ocean (TAO) array of 70 instrument buoys moored throughout the equatorial Pacific Ocean. Beginning in 1985 after the 1982-83 unforecasted El Niño event and completed in 1994, the TAO array gathers surface meteorological and oceanographic data and records ocean temperature to a depth of 500 meters (1650 feet). (note: figure from http://www.pmel.noaa.gov/tao/)

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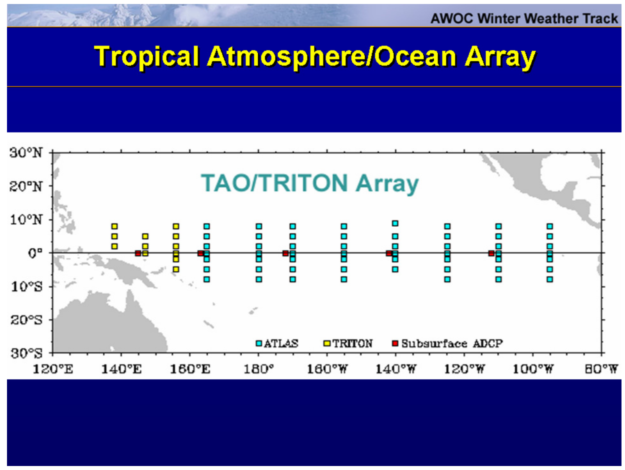

10. Oceanic Niño Index (ONI)

Instructor Notes: Based on the principal measure for monitoring, assessment, and prediction of ENSO (SST departures from average in the Niño 3.4 region). Three-month running-mean values of SST departures from average in the Niño 3.4 region, based on a set of improved homogeneous historical SST analyses (Extended Reconstructed SST – ERSST.v2). The methodology is described in Smith and Reynolds, 2003, J. Climate, 16, 1495-1510. Used to place current conditions in historical perspective. NOAA operational definitions of El Niño and La Niña are keyed to the index. (note: figure from http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.shtml)

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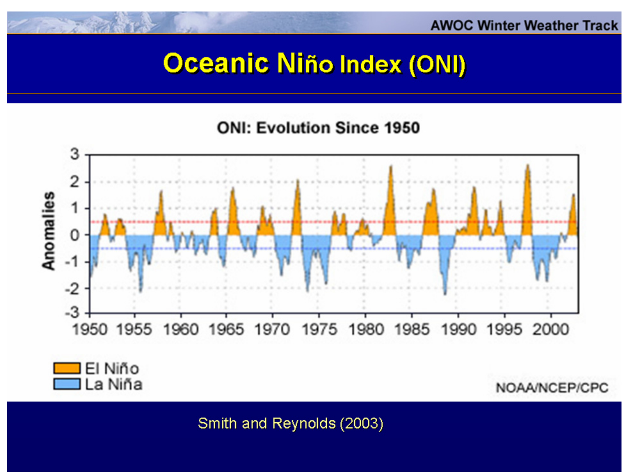

11. So What is the “SO”?

Instructor Notes: It was the atmospheric part of ENSO, i.e. the Southern Oscillation, that first attracted the attention of scientists. Sir Gilbert Walker documented and named the SO in the 1930s. The clearest sign of the SO is the inverse relationship between surface air pressure at two sites: Darwin, Australia, and the South Pacific island of Tahiti. So Why do we have ENSO? The basic answer is that it appears to be a necessary mechanism for maintaining long-term climate stability (i.e. transport heat from the Tropics to the higher latitudes). El Niño acts to more effectively remove heat from the large tropical Pacific Ocean, and transfer this heat to higher latitudes via the atmospheric circulation. El Niño-like events can occur in the tropical Atlantic, but much less frequently and with minimal regional impacts. (note: data from http://www.earthscape.org/t1/heb01/)

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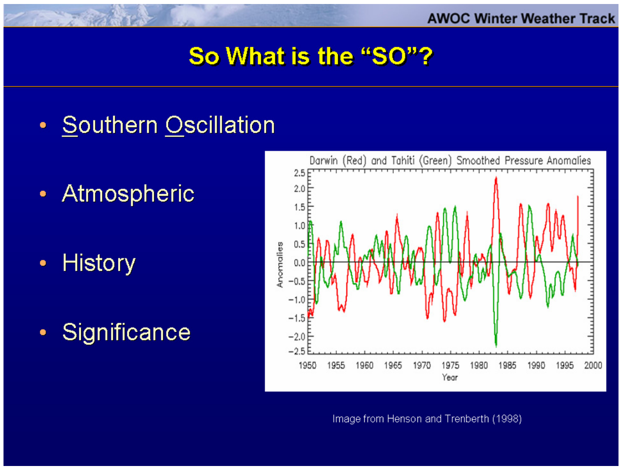

12. The Location of ENSO

Instructor Notes: Convection in the tropics is the "bridge" which translates the SST anomalies (El Niño or La Niña) into an atmospheric response, as identified by the Southern Oscillation.

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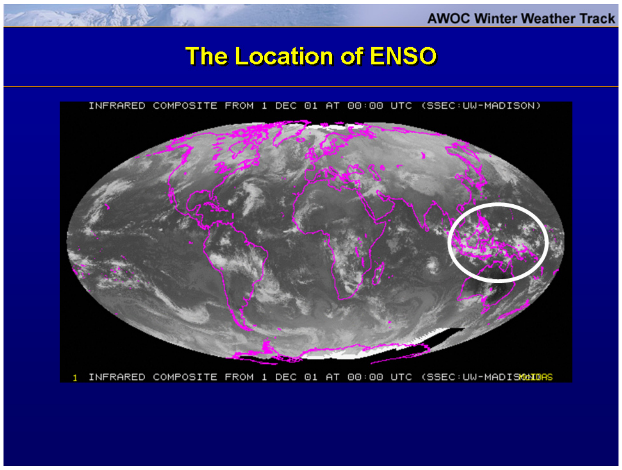

13. Normal Conditions

Instructor Notes: This two-dimensional picture was extended vertically by Jacob Bjerknes in 1969. He noted that trade winds across the tropical Pacific flow from east to west. To complete the loop, he theorized, air must rise above the western Pacific, flow back east at high altitudes, then descend over the eastern Pacific. Bjerknes called this the Walker circulation; he also was the first to recognize that it was intimately connected to the oceanic changes of El Niño and La Niña. (note: figure from http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.shtml)

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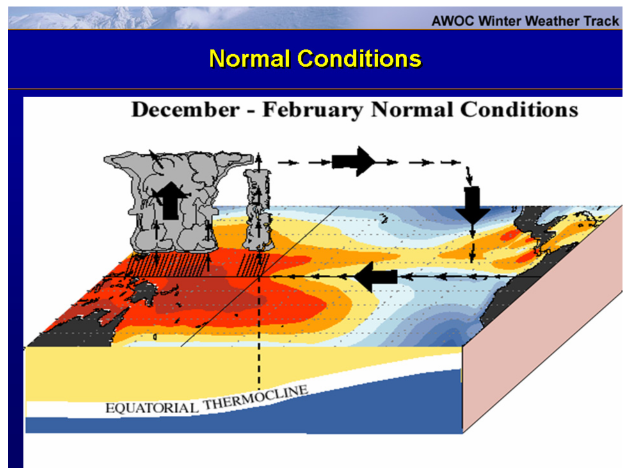

14. El Niño Conditions

Instructor Notes: Near the end of each calendar year ocean surface temperatures warm along the coasts of Ecuador and northern Peru. Local residents referred to this seasonal warming as “El Niño”, meaning The Child, due to its appearance around the Christmas season. Every two to seven years a much stronger warming appears, which is often accompanied by beneficial rainfall in the arid coastal regions of these two countries. Over time the term “El Niño” began to be used in reference to these major warm episodes. El Niño is closely related to a global atmospheric oscillation known as the Southern Oscillation (SO). During El Niño episodes lower than normal pressure is observed over the eastern tropical Pacific and higher than normal pressure is found over Indonesia and northern Australia. This pattern of pressure is associated with weaker than normal near-surface equatorial easterly (east-to-west) winds. These features characterize the warm phase of the SO, which is often referred to as an El Niño/Southern Oscillation (ENSO) episode. During warm (ENSO) episodes the normal patterns of tropical precipitation and atmospheric circulation become disrupted. The abnormally warm waters in the equatorial central and eastern Pacific give rise to enhanced cloudiness and rainfall in that region, especially during the boreal winter and spring seasons. At the same time, rainfall is reduced over Indonesia, Malaysia and northern Australia. Thus, the normal Walker Circulation during winter and spring, which features rising air, cloudiness and rainfall over the region of Indonesia and the western Pacific, and sinking air over the equatorial eastern Pacific, becomes weaker than normal, and for strong warm episodes it may actually reverse.

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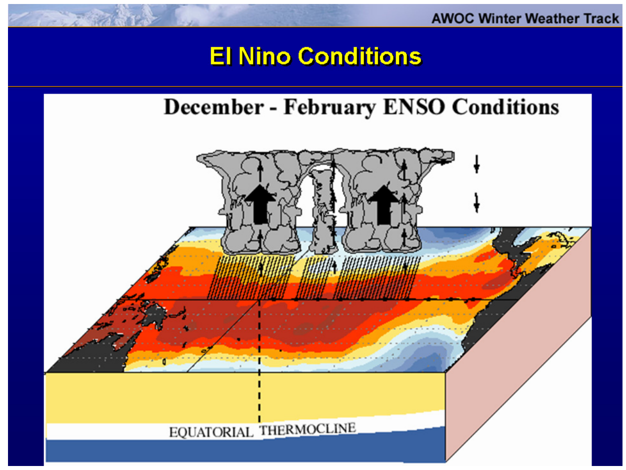

15. La Niña Conditions

Instructor Notes: At times ocean surface temperatures in the equatorial central Pacific are colder than normal. These cold episodes, sometimes referred to as La Niña episodes, are characterized by lower than normal pressure over Indonesia and northern Australia and higher than normal pressure over the eastern tropical Pacific. This pressure pattern is associated with enhanced near-surface equatorial easterly winds over the central and eastern equatorial Pacific. During cold (La Niña) episodes the normal patterns of tropical precipitation and atmospheric circulation become disrupted. The abnormally cold waters in the equatorial central give rise to suppressed cloudiness and rainfall in that region, especially during the Northern Hemisphere winter and spring seasons. At the same time, rainfall is enhanced over Indonesia, Malaysia and northern Australia. Thus, the normal Walker Circulation during winter and spring, which features rising air, cloudiness and rainfall over the region of Indonesia and the western Pacific, and sinking air over the equatorial eastern Pacific, becomes stronger than normal.

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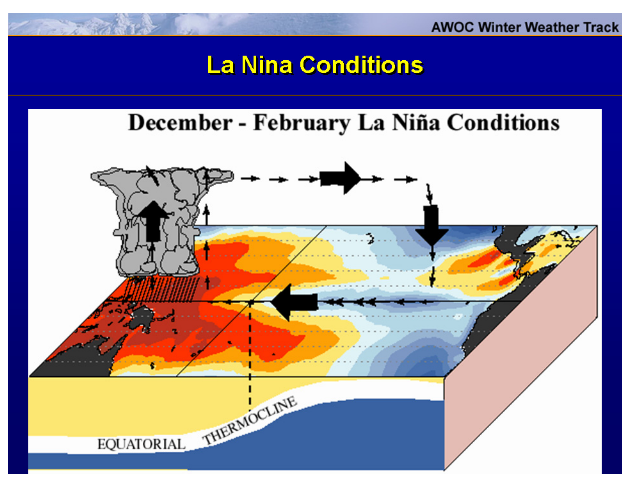

16. What About Subsurface?

Instructor Notes: The evolution of the El Niño and La Niña, as well as the transition between the extreme phases of the ENSO cycle, depends greatly on the subsurface ocean temperature structure and the variability of the low-level winds. As an El Niño episode evolves, significant changes occur in both the subsurface temperatures and in the depth of the oceanic thermocline (The thermocline separates the warm upper ocean from the cold deep ocean waters.). In the early stages of El Niño episodes the oceanic thermocline is deeper than normal in the western and central equatorial Pacific, in association with an abnormally deep pool of warm ocean water throughout the region. As El Niño episodes progress to the mature phase, the depth of the thermocline gradually decreases in the central and western equatorial Pacific and increases in the eastern equatorial Pacific, in response to weaker-than-average low-level easterly winds. As a result, subsurface temperatures become cooler than normal in the western equatorial Pacific, and warmer than normal across the eastern equatorial Pacific. In the latter stages of El Niño episodes, both the depth of the thermocline and subsurface temperatures become less than normal throughout most of the equatorial Pacific as the heat in the upper ocean is gradually depleted. Thus, the warmer than normal temperatures become increasingly confined to a shallow layer near the ocean surface in the eastern equatorial Pacific, setting the stage for a transition to either a neutral state or to a La Niña episode. This transition process is critically dependent on the evolution of the low-level atmospheric winds. For example, if the easterly winds strengthen sufficiently, they can produce upwelling over the eastern equatorial Pacific, bringing the cold ocean waters to the surface. If the drop in sea surface temperatures is sufficiently large, it can lead to the onset of La Niña conditions. Conversely, in the early stages of La Niña episodes the thermocline is generally shallower than normal across the equatorial Pacific. The thermocline gradually deepens in the western Pacific during the mature phase of La Niña episodes, and in the central Pacific during the latter stages of the episode. As a result, the subsurface temperatures become warmer than normal in these regions, while the ocean surface temperatures remain colder than normal. This decrease in the overall volume of abnormally cold ocean waters indicates an increase in the upper ocean heat content, and results in conditions more favorable for a transition to either a neutral state or to an El Niño episode. Once again the critical factors in the transition are the low-level winds and the subsurface temperature structure. The persistent easterly trade winds are a key ingredient in the ENSO process. Trade winds push water toward the western Pacific. The sea level in the Philippines is normally about 60 centimeters (23 inches) higher than the sea level on the southern coast of Panama. They also allow the westward-flowing water to remain near the surface and gradually heat. This gives the water's destination-the western Pacific-the warmest ocean surface on Earth. As warm surface water collects in the western Pacific, it tends to push down the thermocline, the boundary separating well-mixed surface waters from deeper, colder waters.

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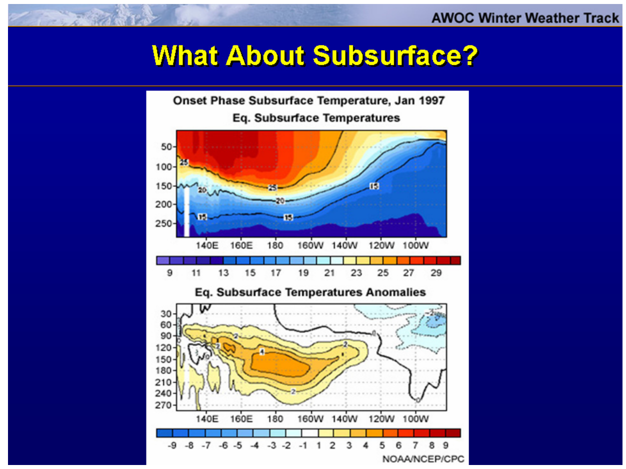

17. An Adjustment to the Jet Stream

Instructor Notes: The primary atmospheric response to these SST anomalies is an adjustment to the jet stream as the Walker circulation adjusts due to new convective patterns. Convection tends to be longer lived over SSTs of 28 degrees C or greater. Thus a shift in warm SSTs eastward will have a dramatic effect on where convection will be longer lived and hence, adjust the location of the jet stream.

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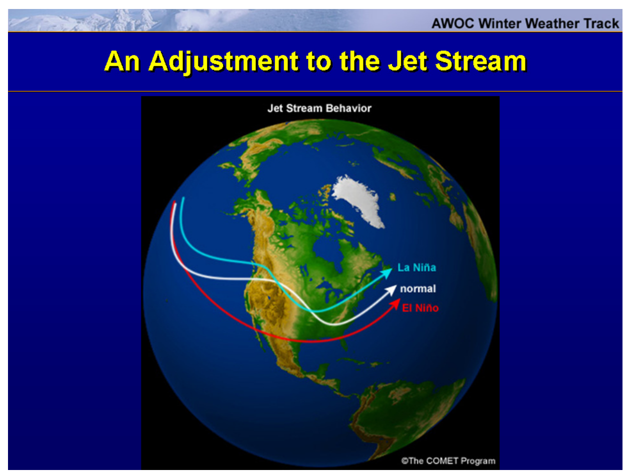

18. January-March Upper-Level (200-hPa) Circulation Variability during El Niño Episodes

Instructor Notes: Relative to ENSO-neutral (above), El Niño features are stronger than average with westerly winds over the subtropical eastern Pacific, and a southward shifted jet stream over the east Pacific and the contiguous US, with increased westerly winds and storminess over the Southwest and Gulf Coast states. (note: figures prepared by Climate Prediction Center)

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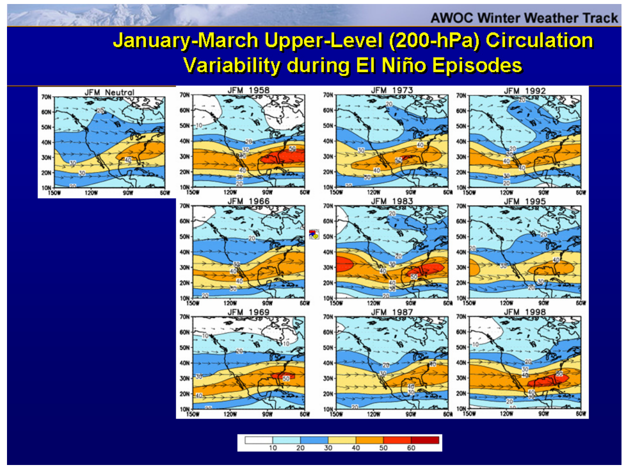

19. Typical El Niño Winter Pattern

Instructor Notes: During winter El Niño episodes feature a strong jet stream and storm track across the southern part of the United States, and less storminess and milder-than-average conditions across the North. El Niño episodes are associated with four prominent changes in the wintertime atmospheric flow across the eastern North Pacific and North America. The first is an eastward extension and southern shift of the East Asian jet stream from the International Date Line to the southwestern United States. The second is a more west-to-east flow of jet stream winds than normal across the United States. The third is a southward shift of the storm track from the northern to the southern part of the United States. The fourth is a southward and eastward shift of the main region of cyclone formation to just west of California. This shift results in an exceptionally stormy winter and increased precipitation across California and the southern U.S, and less stormy conditions across the northern part of the country. Also, there is an enhanced flow of marine air into western North America, along with a reduced northerly flow of cold air from Canada to the United States. These conditions result in a milder than normal winter across the northern states and western Canada. (note: figure from http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.shtml)

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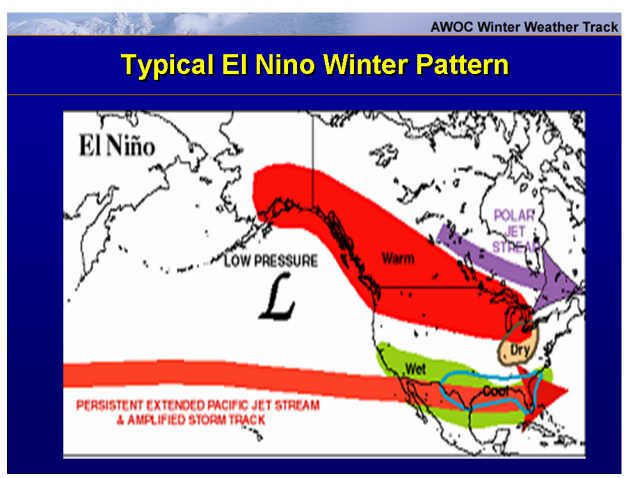

20. El Niño

Instructor Notes: During the winter, in the Tropics, El Niño episodes are associated with increased rainfall across the east-central and eastern Pacific and with drier than normal conditions over northern Australia, Indonesia and the Philippines. Elsewhere, wetter than normal conditions tend to be observed along coastal Ecuador, northwestern Peru, southern Brazil, central Argentina, and equatorial eastern Africa. El Niño episodes also contribute to large-scale temperature departures throughout the world, with most of the affected regions experiencing abnormally warm conditions during NH winter. Some of the most prominent temperature departures include: 1) warmer than normal conditions across southeastern Asia, southeastern Africa, Japan, southern Alaska and western/central Canada, southeastern Brazil and southeastern Australia and cooler than normal conditions along the Gulf coast of the United States. (note: Data from CPC)

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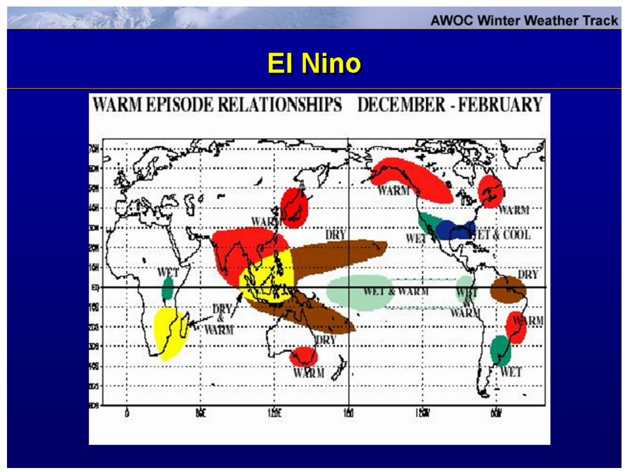

21. Example: El Niño of 1998

Instructor Notes: During El Niño, rainfall and thunderstorm activity diminishes over the western equatorial Pacific, and increases over the eastern half of the tropical Pacific. This area of increased rainfall occurs where the exceptionally warm ocean waters have reached about 28 degrees C or 82 degrees F. This overall pattern of rainfall departures spans nearly one-half the distance around the globe, and is responsible for many of the global weather impacts caused by El Niño. In the left-hand panel the seasonal rainfall totals during the strong El Niño conditions of January-March 1998 are shown for over the Pacific Ocean, the United States, and South America. The heaviest rainfall [in units of millimeters (mm)] is shown by the darker green and blue colors, and lowest rainfall is shown by the lighter green colors. Since 25.4 mm is equal to one inch of rain, we see that the rainfall totals are more than 800 mm just south of the equator along the International Date Line (indicated by the 180 label), which is more than 31 1/2 inches of rain. And nearly double the normal amount. In the right-hand panel the January-March 1998 seasonal rainfall departures from average are shown. The areas with well above average rainfall are shown by darker green colors, and the areas with well below-average rainfall are shown by the darker brown and yellow colors. The rainfall departures are shown in units of 100 millimeters. We see that the seasonal rainfall totals were more than 400 mm above normal just south of the equator along the International Date Line (indicated by the 180 label), which is more than 15 3/4 inches above normal. Considerable rainfall also occurred farther north (near 40 degrees N) over the central and eastern North Pacific, and across the western and southeastern United States. These areas lie along the main wintertime storm track, which brings above-average rainfall to the western and south-eastern United States. In contrast, the seasonal rainfall totals over the western Pacific just north of the equator were less than 100 mm during the season (see left-hand panel), which is more than 800 mm (or 31 1/2) inches) below normal. This extreme dryness led to a series of major uncontrolled wildfires in Indonesia. (note: figure from http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.shtml)

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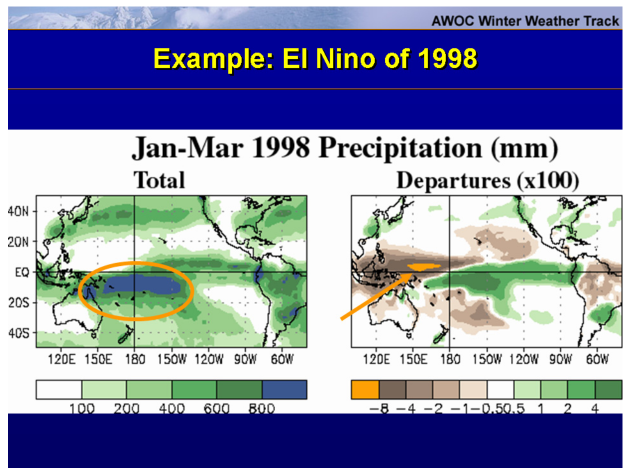

22. January-March Upper-Level (200-hPa) Circulation Variability during La Niña Episodes

Instructor Notes: Relative to ENSO-neutral (above) La Niña often features weaker than average westerly winds over the subtropical eastern Pacific (red circled regions), a Note a northward shifted jet stream over the east Pacific with increased westerly winds over the Pacific NW, and considerable event-to-event variability in the position of the jet stream along the East Coast.

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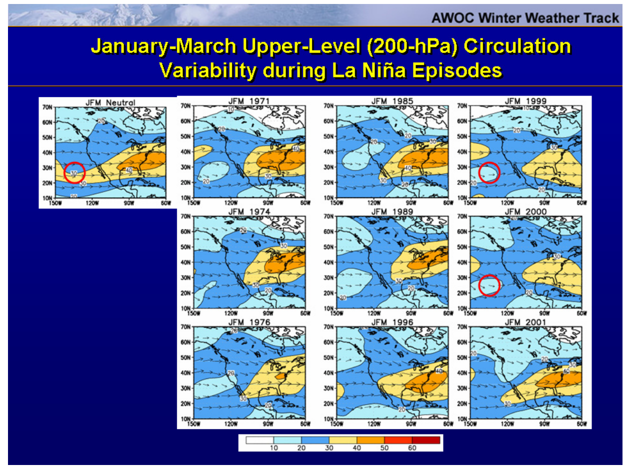

23. Typical Winter La Niña Pattern

Instructor Notes: La Niña episodes are associated with three prominent changes in the wintertime atmospheric flow across the eastern North Pacific and North America. The first is an amplification of the climatological mean wave pattern and increased meridional flow across the continent and the eastern North Pacific. The second is increased blocking activity over the high latitudes of the eastern North Pacific. The third is a highly variable strength of the jet stream over the eastern North Pacific, with the mean jet position entering North America in the northwestern United States/ southwestern Canada. Accompanying these conditions, large portions of central North America experience increased storminess, and an increased frequency of significant cold-air outbreaks, while the southern states experiences less storminess and precipitation. Also, there tend to be considerable month-to-month variations in temperature, rainfall and storminess across central North America during the winter and spring seasons, in response to the more variable atmospheric circulation throughout the period. (figure from http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_cycle.shtml)

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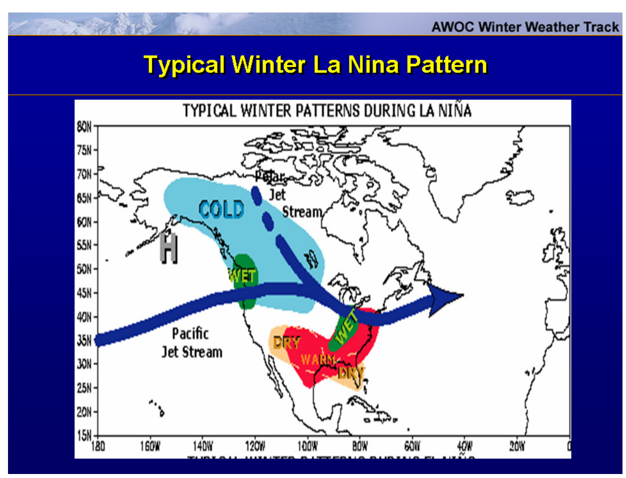

24. What About La Niña?

Instructor Notes: During La Niña episodes rainfall is enhanced across the western equatorial Pacific, Indonesia and the Philippines and is nearly absent across the eastern equatorial Pacific. Elsewhere, wetter than normal conditions tend to be observed during December-February (DJF) over northern South America and southern Africa, and during June-August (JJA) over southeastern Australia. Drier than normal conditions are generally observed along coastal Ecuador, northwestern Peru and equatorial eastern Africa during DJF, and over southern Brazil and central Argentina during JJA. La Niña episodes also contribute to large-scale temperature departures throughout the world, with most of the affected regions experiencing abnormally cool conditions. Some of the most prominent temperature departures include: 1) below-normal temperatures during December-February over southeastern Africa, Japan, southern Alaska and western/central Canada, and southeastern Brazil; 2) cooler than normal conditions during June-August across India and southeastern Asia, along the west coast of South America, across the Gulf of Guinea region, and across northern South America and portions of central America; and 3) warmer than normal conditions during December-February along the Gulf coast of the United States.

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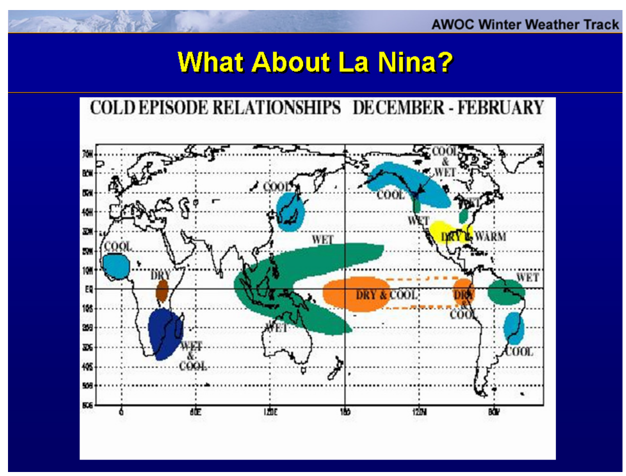
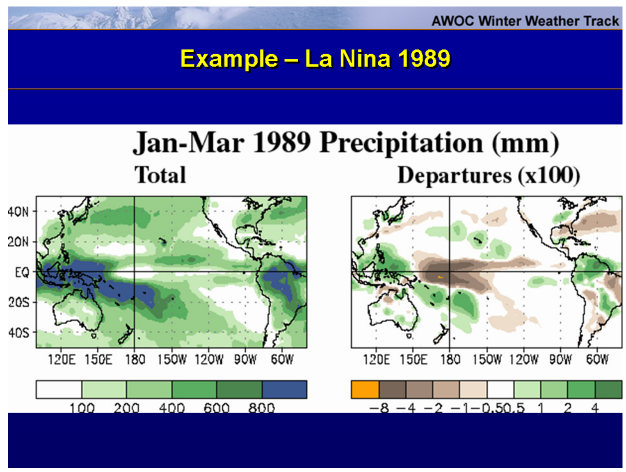


25. Example – La Niña 1989

Instructor Notes: During La Niña, rainfall and thunderstorm activity diminishes over the central equatorial Pacific, and becomes confined to Indonesia and the western Pacific. The area experiencing a reduction in rainfall generally coincides quite well with the area of abnormally cold ocean surface temperatures. This overall pattern of rainfall departures spans nearly one-half the way around the globe, and is responsible for many of the global weather impacts caused by La Niña. In the left-hand panel (from CPC web site) you can see the seasonal rainfall totals over the Pacific Ocean, the United States, and South America during January-March 1989 when strong La Niña conditions were present. The heaviest rainfall is shown by the darker green and blue colors, and lowest rainfall is shown by the lighter green colors. The rainfall totals are shown in units of millimeters (mm). Since 25.4 mm is equal to 1 inch of rain, we see that the rainfall totals are more than 800 mm over the western tropical Pacific and Indonesia, which is more than 31 1/2 inches of rain. In the right-hand panel you can see the January-March 1989 seasonal rainfall departures from average for strong La Niña conditions. The areas where the rainfall is well above average are shown by darker green colors, and the areas where the rainfall is most below average are shown by the darker brown and yellow colors. These rainfall departures are shown in units of 100 millimeters. We see that rainfall totals were more than 200-400 mm above normal over the western tropical Pacific and Indonesia during the season, which is roughly 8-16 inches above normal! We also see well below-average rainfall across the central tropical Pacific, where totals in some areas were more than 400 mm (15 3/4 inches) below normal.

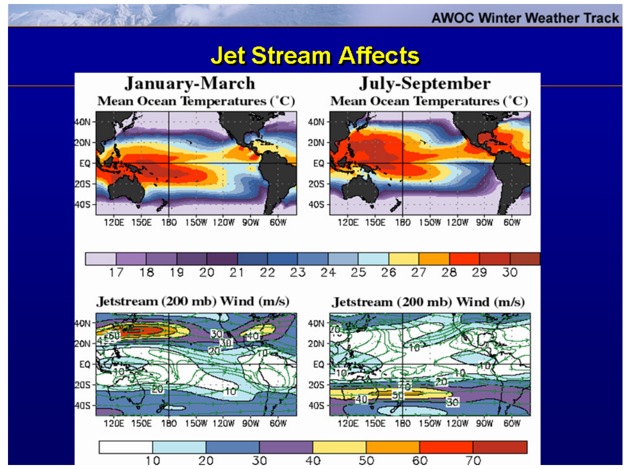
Student Notes:



26. Jet Stream Affects

Instructor Notes: Pacific ocean temperatures (from CPC), tropical rainfall and vertical motion patterns greatly affect the distribution of atmospheric heating across the tropical and subtropical Pacific. Normally, the strongest heating and warmest air temperatures coincide with the warmest ocean waters and heaviest rainfall. This atmospheric heating helps determine the overall north-south temperature differences in both hemispheres, which significantly affects the strength and location of the jet streams over both the North and South Pacific. This influence on the jet streams tends to be most pronounced during the respective hemisphere's winter season, when both the location and eastward extent of the jets (to just east of the date line) exhibit a strong relationship to the pattern of tropical heating. These jet streams are then a major factor controlling the winter weather patterns and storm tracks in the middle latitudes over both North and South America.

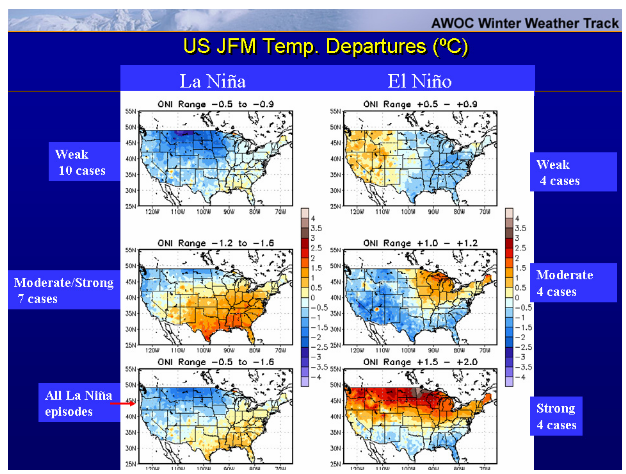
Student Notes:



27. US JFM Temp. Departures (Degrees C)

Instructor Notes: This diagram (from CPC) shows temp departures for a number of ENSO cases. You can see on the left hand side, La Niña, that temperature departures were greater in the northern tier during weak cases. Contrast that with strong El Niño, where the northern tier had a very strong warmer than normal signal.

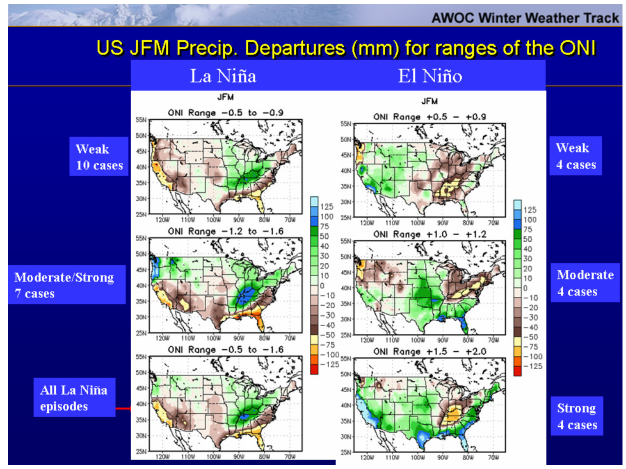
Student Notes:



28. US JFM Precip. Departures (mm) for Ranges of the ONI

Instructor Notes: Now here are the precipitation departures for the different ENSO cases. Here we see the highest departure from normal precipitation conditions in CA are seen in the weak La Niña cases in the upper left corner. However, we do find the largest wet bias occurred during La Niña in western KY and TN in the moderate and strong cases (the left middle image). For El Niño, the Pac NW drier conditions are most pronounced in the moderate cases as is true for the OH and MS valleys. The wetter than normal signals in CA are also correlated with stronger El Niño cases.

Student Notes:



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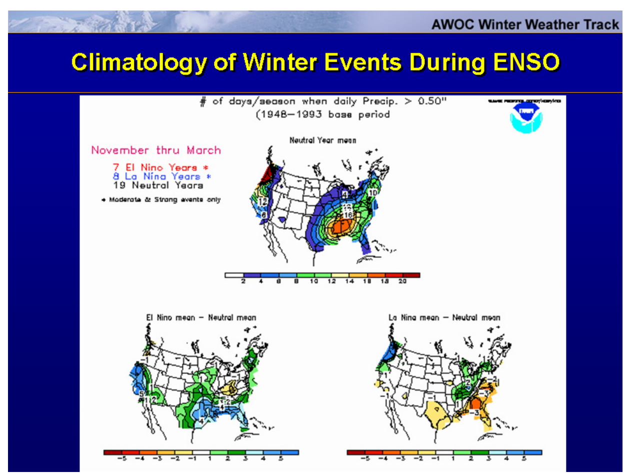
29. Climatology of Winter Events During ENSO

Instructor Notes: Shown from CPC web site are the mean number of days per season (November - March 1948 through 1993) in which precipitation exceeded 0.50 inches for Neutral years (top). Lower left map is the difference in this quantity between El Niño years and Neutral years. Lower right map is the difference in this quantity between La Niña years and Neutral years. Data are analyzed on a 2 degree latitude x 22 degree longitude grid.

Student Notes:



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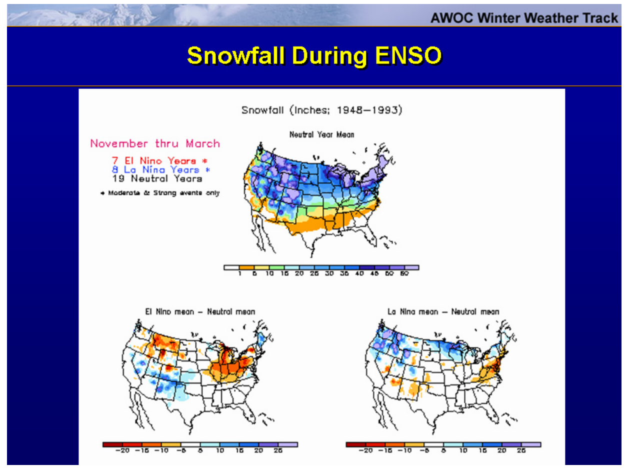
30. Snowfall During ENSO

Instructor Notes: Displayed from CPC, here is the mean seasonal snowfall (November - March 1948 through 1993) in inches for Neutral years (top). The lower left map is the difference in snowfall between El Niño years and Neutral years. The lower right map is the difference in fall between La Niña years and Neutral years. Data are analyzed on a 2 degree x 2 degree grid.

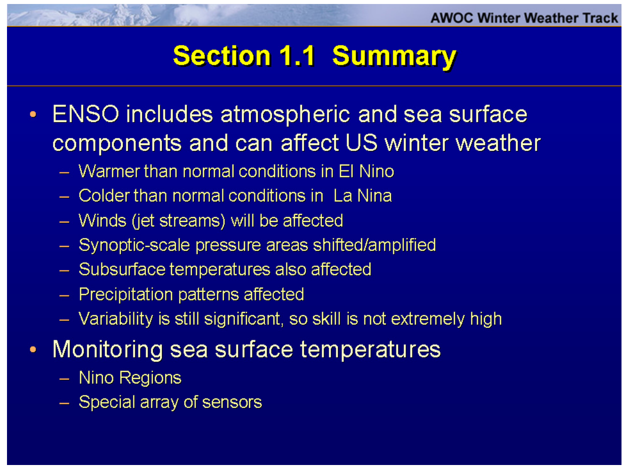
Student Notes:



31. Section 1.1 Summary

Instructor Notes: The El Niño/La Niña and Southern Oscillation ENSO, is typically referred to as the “800 lb. Gorilla” of climate predictability, in that if a moderate strong cold/warm episode occurs, the effects on US weather, particularly in the winter are well documented. It is important to note that other factors (such as teleconnections, the Madden Julian Oscillation, and other large scale influences) can all have an effect on the pattern in any given winter. Nonetheless, we can “isolate” the effects of ENSO on the winter weather in the US. These effects include during El Niño: warmer temperatures across the northern US and colder than normal conditions in the southern US. Precipitation patterns are also affected, with an increase in precipitation noted in the south, while drier conditions typically prevail across the north. During La Niña, cooler and wetter conditions are common in the pacific northwest and into the Great Lakes, while warmer and drier conditions occur in the southern US. It is important to remember that there is a lot of variability from one ENSO event to another, so forecasting synoptic scale events can be quite challenging. Monitoring the sea surface and subsurface temperatures are an important component in determining the state of ENSO and forecasting subsequent seasonal impacts. Scientists use “Niño regions,” especially the Niño 3.4 region to determine what mode the climate system is in and to assess trends or “anomalies.” A special array of sensors have been placed in the tropical pacific to keep close watch of the oceanic temperatures and winds. In the next session we’ll explore another phenomenon which affects winter weather in the US…The Madden Julian Oscillation.

Student Notes:



32. ENSO Quiz

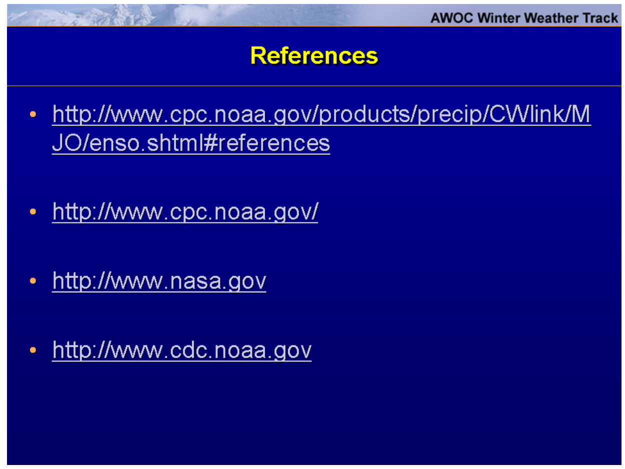
Instructor Notes: Please take a moment to complete this quiz.

Student Notes:

33. References

Instructor Notes: Here are some web sites that you might find useful regarding ENSO.

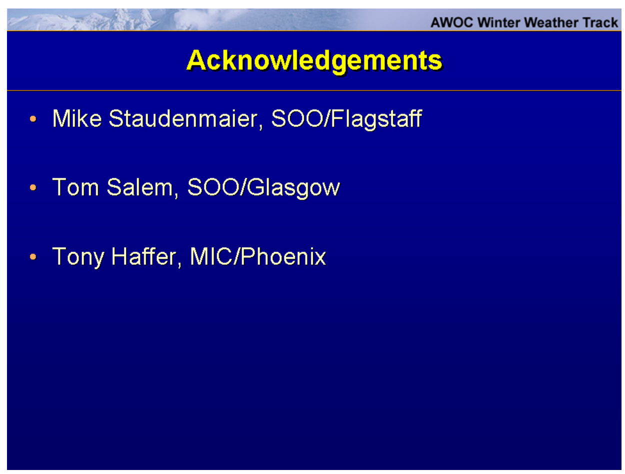
Student Notes:



34. Acknowledgements

Instructor Notes: I'd like to thank the following individuals for the assistance in creating this lesson: Mike Staudenmaier, SOO/Flagstaff Tom Salem, SOO/Glasgow Tony Haffer, MIC/Phoenix

Student Notes:



35. Questions???

Instructor Notes: After going through this lesson if you have any questions, first ask your SOO. Your SOO is your local facilitator and should be able to help answer many questions. If you need additional info from what your SOO provided, send an E-mail to the address on the slide. This address sends the message to all the instructors involved with this IC. Our answer will be CC'd to your SOO so that they can answer any similar questions that come up in the future. We may also consider the question and answer for our FAQ page.

Student Notes: